Computer Simulation of an Anesthesia Service at a U.S. Army Medical Treatment Facility

Jerry A. Cook

Tripler Army Medical Center

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14. ABSTRACT
With the emphasis on cost-saving continuously growing within the Military Health System, the leadership of Tripler Army Medical Center (TAMC) has responded by implementinga corporate style of practice and a business philosophy that prescribes more efficient use of assets. Increased business case analyses and increased cooperation with Queens Health Plans,the local TRICARE sub-contractor, evidence this. One particularly successful example of this cooperation is the use of Resource Sharing Agreements (RSA) a mutually beneficial arrangement where the contractor alleviates an identified specific personnel shortage by providing a health professional to fill that specified position within the hospital. However, TAMC departments often perceive the personnel gained through these RSAs as free labor. This misperception has contributed to an increase in the number of requests within the command as well as the resulting need to further scrutinize the requests. One such request from the hospitals anesthesia service prompted the command to commission this study to analyze empirical data to substantiate the workload and staffing levels within the service. The study was accomplished using a simulation modeling software program and existingas well as gathered data on all the anesthesia service at TAMC. The purpose was to compare not only the overall workload vs. staffing levels, but also the ratio of Certified Registered Nurse Anesthetists (CRNA) to Anesthesiologist Consultants. Three models were built with all factors identical except the number and assignment of the Anesthesiologist Consultants. Analysis of the simulation results indicates that the current workload could still be done after reducing the number of Anesthesiologists. However, the issue of patient safety could keep the staffing at the present level while future increased autonomy for the CRNAs would warrant an even larger cut in Anesthesiologists.

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Abstract

With the emphasis on cost-saving continuously growing within the Military Health System, the leadership of Tripler Army Medical Center (TAMC) has responded by implementing a corporate style of practice and a business philosophy that prescribes more efficient use of assets. Increased business case analyses and increased cooperation with Queens Health Plans, the local TRICARE sub-contractor, evidence this. One particularly successful example of this cooperation is the use of Resource Sharing Agreements (RSA) – a mutually beneficial arrangement where the contractor alleviates an identified specific personnel shortage by providing a health professional to fill that specified position within the hospital.

However, TAMC departments often perceive the personnel gained through these RSAs as “free labor”. This misperception has contributed to an increase in the number of requests within the command as well as the resulting need to further scrutinize the requests. One such request from the hospital’s anesthesia service prompted the command to commission this study to analyze empirical data to substantiate the workload and staffing levels within the service.

The study was accomplished using a simulation modeling software program and existing as well as gathered data on all the anesthesia service at TAMC. The purpose was to compare not only the overall workload vs. staffing levels, but also the ratio of Certified Registered Nurse Anesthetists (CRNA) to Anesthesiologist Consultants. Three models were built with all factors identical except the number and assignment of the Anesthesiologist Consultants.

Analysis of the simulation results indicates that the current workload could still be done after reducing the number of Anesthesiologists. However, the issue of patient safety could keep the staffing at the present level while future increased autonomy for the CRNAs would warrant an even larger cut in Anesthesiologists.

Table of Contents

List of Tables

Computer Simulation of an Anesthesia Service at a U.S. Army Medical Treatment Facility

Introduction

Since the inception of the CHAMPUS Reform Initiative in 1988 and its transition to TRICARE in 1996 the Military Health System (MHS) has progressively moved toward a true managed care mindset and corporate style of conducting business. This is evidenced by the apparent switch in business philosophy from one of financial complacency to one that emphasizes more efficient use of assets (especially in the high cost areas like surgery and anesthesiology).

The leadership of Tripler Army Medical Center demonstrates this corporate style of practice by displaying an increased emphasis on business case analysis and through increased cooperation with Queens Health Plans, the local TRICARE sub-contractor. One particularly successful example of this cooperation is the use of Resource Sharing Agreements (RSA) – an arrangement where the contractor alleviates an identified specific personnel shortage by providing a health professional to fill that specified position within the hospital. Both the facility and the contractor benefit from these arrangements through cost savings and increased ability to provide needed services to beneficiaries within the military treatment facility as opposed to referring them to a civilian facility.

Use of RSAs is not, however, without disadvantages. The primary one is that departments within TAMC may perceive the arrangement as a chance to obtain “free labor”. The result is that the departments will occasionally generate requests that are based on inaccurate documentation or data that depict erroneous requirements. When this occurs it can only be viewed as a benign failure to update business philosophies. The desire of the command at TAMC is to correct this by illustrating the importance of data collection and presentation.

Conditions Which Prompted the Study

The anesthesia service at TAMC submitted a request in March 1998 to add one permanent and three temporary RSA anesthesiologists [Medical Doctor Anesthesiologists – (MDAs)] to the service. Several MDAs were due to leave TAMC or require time off for medical reasons. Early the following September the command asked the anesthesia services to supply data to support the requests. While the service provided prompt information concerning the workload and number of staff needed to support the workload, the command still had questions concerning the validity of the data and the logic surrounding certain practice habits within the anesthesia service at TAMC.

One example of the command's concern was the fact that one MDA was assigned every night to pull "on-call" consultation duty in support of the in-house Certified Registered Nurse Anesthetist (CRNA) who actually administers anesthesia for after-hour cases. The question was asked as to why CRNAs needed in-house consultants during the day but not at night and whether or not this practice habit constituted a lack of equity of care for patients that required surgery after hours. Furthermore, the question was posed why the MDA had the following day off if the duty was to provide consultation by phone versus physically being in the hospital.

Another issue that exists somewhat under the surface of the situation is the lack of consensus within the military anesthesia ranks, as well as within the civilian anesthesia community, regarding the role of MDAs as consultants to CRNAs. CRNA leadership desires more autonomy while the MDA leadership feels increasing the CRNA to MDA ratio (in the capacity as consultant) would compromise the safety of the patients. This seems to be the sentiment among the staff assigned to the anesthesia services at TAMC as well. The result of the dispute is a lack of concurrence concerning the necessary MDA to CRNA ratio as well as the overall validity of the need for MDA consultants.

These issues combined with the fact that no empirical study had been conducted to substantiate the answers provided by the leadership of anesthesia services, prompted the command to commission this investigator to conduct such a study.

Problem Statement

No empirical study has been conducted at TAMC to substantiate that anesthesia workload supports current staffing levels in the anesthesia service.

Literature Review

Anesthesia Staffing Issues

An initial literature search conducted by this investigator revealed that only a few authors have published articles on anesthesia services staffing and productivity. None were applicable to the situation at TAMC and none addressed the issue of MDA/CRNA ratios in an anesthesia service. The prevalent discussion in literature focuses on the area of practice guidelines and types of anesthesia service models (i.e., composition of personnel delivering anesthesia care). There is also, as mentioned in the introduction, an on-going battle over the level of anesthesia care a CRNA is capable of or should be permitted to deliver independent of MDA or MD supervision. Since this issue directly impacts on the relevance of this study these articles are discussed.

Contemporary anesthesia providers deliver a myriad of medical services to patients. The evolution of managed care and the resulting decrease in the volume of surgical patients has resulted in expanded roles for anesthesiology personnel over the last several years. In the past, MDAs and CRNAs mainly delivered anesthesia to the patient undergoing surgery and rarely ventured out of the operating room/post-anesthesia arena. Their roles today many times encompass pre-admission clinics, pain management, and even operating room administration. Indeed, the trend in current literature is to use the word “perioperative” when referring to the role of the anesthesia professional (Erickson & Roizen, 1996).

Authors offer differing opinions regarding the move towards this more diversified “perioperative” role by anesthesia providers. Dr. Rosenberg feels, as his title “The cup is half full” indicates, that the change will be good for the profession. He sees it as a reflection of the superb quality of care that has been delivered by his peers and the resulting request from the medical community for anesthesia providers to take on more duties. (Rosenberg, H. 1997)

On the other hand, Drs. Erickson and Roizen (1996) see the change as a result of being “squeezed from all directions” to do more with the possibility of less pay. They state that the there are numerous sizable and serious problems along the route toward the changes with the formidable one being the likelihood that managed care organizations will not be supportive of the perioperative concept. Dr. Erickson and Dr. Roizen do, however, put a light at the end of the tunnel. They say that the change can be “viewed as potentially disastrous or filled with opportunities” and that the latter will be possible if members of the specialty pull together and adapt to a new way of conducting business (i.e., cutting costs, improving outcomes and bettering marketing efforts).

There are several articles that address staffing from the perspective of what type of provider is the most cost effective and delivers the highest quality of care. One of the most controversial was Drs. Aberstein and Warner’s (1996) article on the roles of the various anesthesia providers, the comparable costs, and four categories that can be used to staff an anesthesia department. They studied anesthesia services in Minnesota based on a legislative directive (MinnesotaCare Bill of 1994) and found that they could classify all anesthesia practices into one of four models: (1) all MDAs; (2) all CRNAs; (3) anesthesia care team practice, where non-MDAs administered anesthesia under the supervision of MDAs (MDAs do not administer anesthesia); and (4) hybrid, where MDAs administered anesthesia to complex patients and supervised the rest. They concluded that the "anesthesia care team practice" was the safest and most cost efficient model.

The article received numerous responses from both the MDA and the CRNA communities to include an official response from the American Association of Nurse Anesthetists (Zambricki, 1996). Some additional conclusions and statements within the article comparing the quality of care and outcomes in regards to CRNA versus MDA were based on old data and unfounded information. The validity of the study and the inferred applicability for anesthesia services in general was questioned by MDAs (Stoelting, 1996) as well as CRNAs (Martin-Sheridan & Wing, 1996; Zambricki, 1996).

Many more articles discuss CRNAs and MDAs in reference to the roles each should play (i.e., supervised and supervisor). They range in specificity from the need for medical direction of CRNAs (from a quality and cost perspective) (Fassett & Calmes, 1995; Silber, 1998), to the medico-legal implications of CRNAs as independent practitioners (Blumenreich, 1997; Blumenreich, 1998;Lack, 1998), to patient satisfaction with CRNAs (Kennedy & Herbert, 1998), all the way to a vision of the hell that would exist should CRNAs be allowed into the British health care industry (as it is in the USA) (Hambly, 1996). The only real conclusions that one can draw from these articles is that: (1) there have been no studies to support or reject either faction's argument and (2) the quality of care from the anesthesia community continues to improve irregardless of the license the provider holds [a conclusion which is supported by the Health Care

Financing Administration (HCFA) (Scott, 1998)].

Simulation

Simulation as a means to model health care systems is a growing field. This growth is due to the growing sophistication of computers along with the need by organizations to test and analyze processes without disrupting overall operations. Simulation allows an organization to test and analyze numerous "What if…?" scenarios, without the risk and expense of actual on-site testing. Other advantages of computer simulation include:

- Accounts for the existence of process variability (e.g., time prior to arrival in surgical suite, overtime period at end of day, etc);
- Reduces cost when compared to actual implementation and testing of each alternative;
- Eliminates or reduces the amount of disruption of current operations;
- Promotes involvement by all those invested in the system and thus promotes total solutions;
- Allows study of the modeled system in compressed time or expanded time modes;
- Enhances ability to incorporate process variability in the simulation and outcomes analysis,
- Increases ability to test an almost unlimited number of variations/combinations of variables;
- Enables visual demonstrations of the application and alternative processes (Bateman, Bowden, Gogg, Harrell, & Mott, 1997; Benneyan, 1997; Law & Kelton, 1991; Williams, Starling, Bircher, Wilks, & Watkins, 1998).

While computer simulation is a powerful tool, it is not the solitary answer for all decision-making problems that are presented. Indeed, there are several drawbacks to using

computer simulation modeling. The first is the fact that the investigator is required to be able to invest a substantial amount of time and money into building a model (Law & Kelton, 1991). Although the relevance of this depends on the size of the model, the purchase of software and the shear amount of "footwork" involved in making the model as accurate as possible (i.e., reviewing blueprints, collecting data, and the transfer of the information into the computer) make this statement valid for any model.

The second drawback to computer simulation is the fact that the investigator and others involved in the study often fail to recognize the limitation of the process. As Pegden, Shannon and Sadowski (1990) contend (as cited in Benneyan, 1997), "the quality of the analysis depends on the quality of the model and the skill of the modeler. Model building is an art, and, as such, the skill of the practitioners varies widely". Some possible causes for simulation failure include:

- Inadequate understanding of statistical concepts, experimental design or simulation;
- Vague or unclear problem statement and objective;
- Failure to involve decision-makers in the process;
- Failure to accurately understand the process being studied;
- Failure to capture appropriate process dependencies and relationships;
- Inappropriate level of detail in the model;
- Failure to capture accurate randomness of the system being modeled;
- Poor or inaccurate data collection;
- Inaccurate use of probability distributions;
- Misuse of animation (e.g., as a way to validate the model);
- Lack of model verification and validation. [Banks & Carson, 1989 (as cited in

Benneyan, 1997); Law & Kelton, 1991; Law & McComas, 1989 (as cited in Benneyan, 1997); Williams et al, 1998].

There are numerous articles where investigators used simulation to evaluate health care systems. The most relevant article is a study conducted by Williams et al (1998) on the "Optimization of Anesthesia Staffing Using Simulation Modeling". The simulation compared cost effectiveness of two models where either two or three anesthesia providers staffed two operating rooms. Although the focus was on overtime reduction and increased time with patients (to increase anesthesia revenue), their conclusions lent insight on how to use alternative staffing patterns in an anesthesia service taking into account quality of care as well as financial issues. Additionally, their status as MDAs offer a certain amount of validity to this investigator's methodology (when presenting information to the TAMC anesthesia service) through their discussion of the advantages and disadvantages of using simulation specific to the surgical environment. Finally, the authors make the profound observation (although it contradicts the title of their article) that simulation models are incapable of generating an optimal solution [textbooks on simulation support using simulation to evaluate alternative solutions vs. optimization (Bonni, C.P., Hausman, W.H., & Bierman, H., 1997; Law & Kelton, 1991).

Another relevant study by Lowery and Martin (1992) used simulation modeling as a method to accurately determine the number of critical beds. The model they built was one of the first to address all of the processes that affect a complex critical care operation to include operating rooms, post anesthesia care and all the critical care beds.

Wolf, et al (1992) discussed the usefulness of simulation modeling and the process they used to project staffing levels for a 700-bed teaching hospital. After building the model, they were able to recognize the other possible uses in regards to alternative personnel, cost effectiveness, and the effects of a changing census.

Saunders, et al (1989) modeled a complex fully integrated emergency room operation to include staff utilization, test turn-around times and patient throughput, and were able to analyze the output to evaluate system efficiency. Lucas, et al (1997) and Lucas, et al (1998) both used a less glamorous yet as effective mathematical simulation program to model trauma call requirements for neurosurgical and orthopedic trauma services (respectively).

Purpose

The purpose of this project was to determine the anesthesia service staffing level and MDA to CRNA staffing ratio that best supports the anesthesia patient workload generated at TAMC. Utilization rates were evaluated using varying numbers of MDAs that are made available to consult with CRNAs during surgical procedures (MDA consultants) as well as how the MDAs are assigned to provide consultation (i.e., assigned to particular CRNAs vs. floating). The enabling objectives are:

- Determine the performance capability of the current anesthesia services.
- Develop alternative MDA to CRNA staffing ratios.
- Determine alternative configurations for MDA when assigned CRNA consultant duties.
- Compare current and proposed staffing levels and ratios. Identify the alternatives that best support the workload based on utilization rates.

Hypotheses:

H_o: The anesthesia services workload as determined from empirical data supports the current staffing levels in anesthesia service.

H_a: The anesthesia services workload as determined from empirical data does not support the current staffing levels in anesthesia service.

H_o: The frequency and duration of MDA consultations as determined from empirical data supports the current MDA to CRNA ratio.

H_a: The frequency and duration of MDA consultations as determined from empirical data does not support the current MDA to CRNA ratio.

Materials and Methods

Description of TAMC Anesthesia Services

The anesthesia services at TAMC can be divided into four main areas of care delivery: Operating Rooms (OR) to include pre- and postoperative care, and after hours coverage; Labor and Delivery (L&D) (24 hour operations); the Surgical Admission Center (SAC); and the Pain Clinic services. Each are staffed with a mixture of MDAs and CRNAs except for the Pain Clinic, which is staffed by MDAs only. The SAC and the Pain Clinic each have fixed hours of operation and the majority of the OR cases are scheduled within a set time frame. However, staff are not released until the OR case or clinic visit is completed. The reverse is also true for the OR in that staff may possibly complete cases early or not be scheduled for a full day due to the nature and complexity of the cases on any given day (i.e., one room may only have one or two cases scheduled for the entire day but the case or cases may not last until the end of the day).

The current staffing for the anesthesia services at TAMC includes 21 CRNAs and 14 MDAs. The CRNA breakout is twelve dedicated to the OR (includes after hour and weekend staffing), four dedicated to L&D, three dedicated to special procedure rooms, one dedicated to the SAC and one faculty for the student CRNA program. The MDA breakout is twelve dedicated to the OR (includes after hour and weekend staffing), one dedicated to L&D, one dedicated to the Pain Clinic and one dedicated to the SAC. The numbers for staffing the OR are a “little soft” for both the CRNAs and MDAs due to factoring in leave, days off, and chiefs of service duties.

Typically, seven CRNAs and four MDAs are each assigned to a series of cases to be performed in a specified room in the OR beginning at 07:00. The CRNAs are usually assigned to those patients less likely to develop problems while under anesthesia (ASA I and II on a scale of I to V, V being the highest risk) and the MDAs are assigned to ASA III and IV patients as well as children under 2 years of age. The twelfth room is assigned to a CRNA that begins at 09:00. Three additional MDAs are available throughout the scheduled day to offer consultation to the CRNAs, as needed.

The CRNAs assigned to L&D are scheduled to one per twelve-hour shift with the other two for weekend and days off rotations. These CRNAs are contracted and are therefore not under the same constraints as the other CRNAs (i.e., the contractor is responsible for providing coverage for rotating on-call duty, sick leave, military duty, etc.). The one MDA assigned to L&D is responsible for responding to any consultation requests from the L&D CRNAs during the regular workday.

Modeling Software

MedModel 3.5 Healthcare Simulation software was used to develop and evaluate the different models. This software enabled the investigator to analyze the data through a built-in program (Stat::Fit) (adds to the validity of the chosen distributions), build a model that is as large as needed and has a large data base, and demonstrate the simulation through animation.

Data Collection

This investigator used three sources of data for this project: (1) recorded patient case data

(Anesthesia “buck-slips”); (2) data gathered through observation (time-motion tool); and (3) expert opinions. The first source of data, recorded patient case data, is an ideal source for gathering data to build representative distributions of patient anesthesia treatment time and staff utilization in the OR and L&D. The MDA or CRNA records the start and stop time of the critical treatment phases of each surgical and L&D case (e.g., time anesthesia is started and stopped, time patient enters room, incision time, etc.) on a worksheet they refer to as a “buck-slip”. The provider also records the name of each provider, by category (MDA, CRNA or Student), that is “assigned” to the case.

Since the buck-slips do not reflect the frequency or duration of MDA consultations, this investigator developed a time-motion tool to record this information through observation (Appendix). The tool was administered by the CRNAs that are assigned OR cases. They collected two weeks worth of data. Initially, this investigator planned to administer this tool using unbiased personnel (e.g., assigned to other areas of the hospital, etc.). Unfortunately, this method of data collection was not possible due to time and personnel constraints. However, this investigator does not feel there will be problem with data integrity due to the fact that, unlike most time-motion studies, the observed MDAs will notice they are being observed regardless of the observer (the OR environment is closed to “outsiders”).

Expert opinions in the form of triangular distributions were used for the amount of time between cases and the SAC operation. Triangular distributions represent the “best guess” of an expert in the area (minimum time, maximum time and most likely time the expert estimates for the process) and can be used when the data reveals no acceptable distribution. The reason for the use of this type of distribution lies in the poor distributions generated by initial data collected from the two processes (Stat::Fit analysis).

307 records (anesthesia case worksheets) were used to pull data (two weeks worth) for the OR. Of the 307, 48 patient worksheets were L&D cases. These were excluded from the OR

distributions and used for determining workload for the L&D. 135 encounters or consults were recorded by the CRNAs during the two week data collection period using the time-motion tool. Cases where a student CRNA was listed as the primary provider were excluded since students are not included in the service staffing numbers. Additionally the students are under continuous supervision during the case and therefore cannot record "MDA consultations" on the time-motion tool.

Models Simulated

This investigator simulated three models for this study. All three are identical in physical layout. In each model the OR, the L&D and the SAC were included and have the same dimensions as those in the actual hospital. The Pain Clinic was excluded due to the fact all patients seen there are scheduled throughout the duty day and only one MDA is assigned to the clinic.

Each model also included all relevant personnel (resources) that could affect patient arrival and provision of anesthesia care. These included CRNAs and MDAs that work in the OR, L&D and the SAC as well as those personnel whose workloads were not analyzed (e.g., gurney attendants, registered nurses (RN) that work in the SAC, etc.).

The three models also used the same distributions for patient arrival and resource utilization. Anesthesia treatment times were divided into one hour or less, one to two hours, two to three hours and three hours or more.

The major difference in the models was the number and configuration of MDA consultants. The first model simulated three MDA consultants each assigned to specific rooms.

The second model also utilized three MDAs, but the three were free to “float” to whichever room needs them. The third model utilized two free-floating MDA consultants.

Assumptions

This study requires the investigator to make several assumptions in order to consider the effort as worthwhile and to eventually attain any useful conclusions. The first assumption is that CRNAs must have MDAs available to them for the purpose of consultation. Although there is no consensus in current literature to support this assumption, the current philosophy in the Military Health Service is that the consultation services MDAs provide to CRNAs is necessary to avoid increased morbidity and mortality [as discerned from: (1) e-mail conversations dated 19 March 1998 through 1 May 1998 between TAMC Managed Care Division and Anesthesia Services; and (2) personal conversation with the Chief of Anesthesiology/Operative Services, TAMC (September through December 1998)]. This investigator will therefore use the later perspective to best simulate the conditions at TAMC.

The second assumption is that two hundred fifty repetitions represents one year’s worth of operations. Weekend operations were excluded by design since the true emphasis on utilization was on those scheduled cases where MDAs consult with CRNAs.

The third assumption is that the patient-scheduling pattern in the Pain Clinic requires one MDA dedicated per day to operate and therefore does not need to be an active part of the simulation. This is due to the fact the clinic operates similarly to other clinics in that at least one practitioner must be available in order to make the clinic viable, along with the fact that there is no interaction with the CRNAs in clinic operation.

The fourth assumption is that the data collected by the CRNAs regarding MDA consultant utilization will be unbiased. Although this may seem a risky assumption to make, this investigator believes that any bad data will be filtered out when it is fitted against an acceptable distribution.

Results

Processing the collected data through Stat::Fit produced acceptable distributions (as determined by goodness of fit) for anesthesia treatment times in the OR and L&D as well as for MDA consultation times (i.e., time between consults and time spent on each consult). The distributions of each category of anesthesia treatment times (except one hour and below) and MDA consultation times were Weibull distributions. One hour and below data produced a Pearson 6 distribution.

Output from running each model through 250 replications produced a bounty of information. However, since much of the information is not relevant to this study, only a small portion of the results is listed in Tables 1-3 in Appendix B. The most relevant of the listed results concerns the percent utilization of the MDAs. While the mean utilization rates for the three MDA consultants in the three floating MDA model (72.55%, 62.38%, and 50.78%) and the three assigned MDA model (65.37%, 49.33%, and 50.95%) are relatively good, the mean utilization rates for the two MDA consultants in the two MDA model were the highest (81.14% and 75.14%).

An analysis of variance (ANOVA) of the MDA Consultant mean utilization rates revealed a significant difference in the three rates (Table 4 – $F > 3$, $p \leq .05$). Conversely the ANOVA for the mean utilization rates for other OR personnel (i.e., CRNAs; MDAs as practitioners vs. consultants) showed no significant difference between the models (Table 4 – $F <$

3, p >. 05). An ANOVA was not conducted on the utilization rates of the SAC and L&D personnel due to the fact these parts of the model were not inter-connected to the OR.

Discussion

A large amount of data was gathered and evaluated for most of the operations within the anesthesia service at TAMC. Only a small part, however, proved to be relevant to the question of whether or not the workload supports the number of staff. The SAC was evaluated simply to put a number to the work being conducted and to give insight as to the need for a CRNA and a MDA. The numbers in all three models show a high utilization rate for both providers (68% to 72%). Key to this, however, is the fact that the clinic is a scheduled clinic and some of the patients must be interviewed by the MDA due to their level of health risk. Therefore, two providers are a necessity for the operation of the SAC.

Operations within L&D were also analyzed through the model. The percent utilization for the CRNAs was consistently high for all three models (87.45% to 87.55%). This too is only a verification of the amount of work being done. The number of CRNAs assigned to the area cannot fluctuate. This is just enough to cover two twelve-hour shifts and provide two for rotations. Likewise, the one MDA consultant assigned to the L&D must remain so long as scopes of practice dictate that CRNAs require consultation. Unfortunately, no data was available to evaluate the percent utilization of the MDA.

After justifying the number of personnel assigned to the other areas of anesthesia services, the focus in analyzing the three models should center on the operations in the OR. In order to conduct this analysis the workload met by each anesthesia provider type must be evaluated. The MDA providers will be the first providers evaluated followed by the OR CRNAs and finally the MDA consultants.

Although the utilization rates for those MDAs that are assigned to cases as primary anesthesia providers dropped as low as 51%, this is more a reflection of the type of cases to which they are assigned. Current scopes of practice guidelines require that MDAs (vs. CRNAs) provide anesthesia to the sicker patients or those that have a higher health risk (e.g., ASA III and IV, plus children under 2). The models assigned these patients according to the data distributions and the relative percentage of these type cases MDAs treat each day. Typically these cases are either very long (which means fewer cases per day with a strong possibility of fewer total hours in the OR) or very short (e.g., tubes for children's ears, etc.).

The CRNAs utilization rates also dropped to a fairly low level (68.83% for the regularly scheduled cases). However, since there were < .1 failed attempts to enter the system on any of the models (i.e., all patients were treated) and the models were designed to assign patients to CRNAs or MDAs as soon as they were free the low number can again be attributed to the distributions. One example of how this may happen is a case where the CRNA is free, but the next patient to arrive has to be assigned to a MDA (ASA III or IV). This would result in a reduction in the utilization rate for the freed CRNA.

Regardless of the utilization rates for the MDA providers and CRNAs, the OR must have eleven or twelve anesthesia providers to operate as long as the respective number of rooms and cases are booked each day. This possible lack of efficiency can only be attributed back to the surgery services with the anesthesia providers working where and when the surgical schedule dictates. As far as the question of whether CRNAs or MDAs should be used and what are the relative costs involved, that can only be determined by following the current scope of practice guidelines.

Since CRNAs and MDA providers utilization rates are a function of the surgical services, the real question must center on the number of MDA consultants and how varying that number can effect efficiency. In comparing the relative utilization rates of the three models, it is apparent that from a strictly analytical standpoint two MDA consultants can handle the workload that three are currently assigned. Therefore, that model is the most efficient. The problem arises, however, of what would happen if an emergency arises and both MDA consultants are busy consulting. The probability that one or more MDA consultant would be available to help with an emergency is .76 for three floating MDAs, .83 for three assigned MDAs, and .39 for two floating MDAs (using average utilization rates for each model and assuming independence). Would accepting the higher utilization rate of the two MDA model and the resulting lower availability rate be a case of holding efficiency as a higher priority over patient safety? Or could the anesthesia service ensure a system is in place where the emergency consults would pre-empt the routine consults? Unfortunately, it is beyond this investigators clinical knowledge to answer these questions.

As a final area for discussion, this investigator benchmarked the findings of the study against other staffing models available within TAMC. The figures in Table 5 reveal that for the number of required MDAs to match the workload the model results most closely resemble the findings of the most recent Automated Staffing Assessment Model (ASAM) study. The CRNA requirements as determined from the model, however, are lower than both the Table of

Distribution and Allowances (TDA – a military document for authorized staffing) and the ASAM. The relevant point of the comparison is that the numbers produced from the model are relatively close to those produced from other studies and manning documents.

Conclusion and Recommendations

This investigator has accomplished at least one goal - to provide the command with an empirical study of the data to either substantiate or refute the claim that anesthesia workload supports current staffing levels in the anesthesia service at TAMC. The initial conclusion, based on a "bean counters" mindset, is that current workload could be accomplished with one less MDA consultant. From a clinical standpoint, however, the extra consultant may be needed to maintain a level of security against emergencies. Either way, the real question that has surfaced during this study is one that is completely beyond the capabilities of this investigator to answer. It is the question of the role of the MDA as a consultant.

After the completion of the data collection phase of this study, this investigator has discovered several changes that have been made that either currently effect the study or will in the near future. The first change was that now MDA consultants pull call in house. This was implemented in order to ensure a consistent standard of care. The second change that is on the horizon is the possible change in the scopes of practice for both the MDA and CRNA in the Military Health System. If CRNAs are given more autonomy, the question of how many MDA consultants are required and what role they play may be moot.

There are several recommendations this investigator has concerning further use of this study. The first use could be to incorporate fiscal data (e.g., cost of operating surgical suite, cost of personnel, etc.) into the model in order to expand the study into a cost effectiveness study.

Although the issue of cost in the surgical arena in the MHS has not been of great concern, that posture is quickly changing as more and more health positions are filled with contracted personnel. A second use of this model should be to study general OR operations (e.g., number of cases per year, present efficiency of space utilization, etc.). The fact that this is the first template of the OR operations would make it ideal for this purpose. Finally, the research this investigator conducted concerning issues surrounding relationships between CRNAs and MDAs could be used by an investigator with more clinical expertise, along with the model, to explore the possibility of changing the scopes of practice for both the CRNA and MDA in the MHS.

Appendix A

Sample Time-Motion Tool

Date	RM #/ case #	ASA	Length	MD consulted (phone/in room/prior)	Start (time)	End (time)

Appendix B

Descriptive Statistics Tables

Table 1.

Descriptive Statistics for Two Floating Anesthesiologist Consultants Model

Statistic (% Time Use)	Mean	Median	Low 90% CI	High 90% CI
AnesMD1.1	81.14	82.95	80.17	82.10
AnesMD1.2	75.14	76.84	73.80	76.48
Anesthesiologist.1	81.73	84.11	79.94	83.51
Anesthesiologist.2	76.18	81.55	73.82	78.54
Anesthesiologist.3	67.87	73.72	64.87	70.86
Anesthesiologist.4	61.13	67.78	57.67	64.60
CRNA.1	91.91	93.96	91.05	92.77
CRNA.2	90.21	92.28	89.26	91.17
CRNA.3	87.62	91.27	86.35	88.90
CRNA.4	82.79	87.36	81.09	84.50
CRNA.5	77.53	82.40	75.73	79.33
CRNA.6	75.17	81.12	73.06	77.27
CRNA.7	70.02	73.73	67.59	72.45
CRNA2 (15:00-06:00)	54.02	55.56	52.69	55.34
CRNA3 (09:00-17:00)	63.45	63.48	60.94	65.95
Ldr_crna	87.47	98.07	85.58	89.35
sac_anesmd	70.29	71.31	69.41	71.16
sac_CRNA	68.01	68.67	67.13	68.88

LEGEND

AnesMD1.............. Anesthesiologist Consultant

Anesthesiologist.... Anesthesiologist assigned to surgical patients

CRNA .... Certified Registered Nurse Anesthetist (CRNA) assigned to surgical patients

Ldr_crna .... CRNA Assigned to Labor and Delivery

sac_anesmd .... Anesthesiologist assigned to Surgical Admission Center

sac_CRNA .... CRNA Assigned to Surgical Admission Center

Table 2.

Descriptive Statistics for Three Floating Anesthesiologist Consultants Model

Statistic (% Time Use)	Mean	Median	Low 90% CI	High 90% CI
AnesMD1.1	70.56	70.63	69.71	71.42
AnesMD1.2	60.62	61.05	59.49	61.74
AnesMD1.3	49.40	49.09	48.03	50.78
Anesthesiologist.1	81.18	85.71	79.22	83.14
Anesthesiologist.2	74.71	77.97	72.37	77.05
Anesthesiologist.3	66.22	68.76	63.33	69.11
Anesthesiologist.4	55.67	59.00	52.15	59.20
CRNA.1	92.28	94.47	91.47	93.10
CRNA.2	90.12	92.55	89.12	91.12
CRNA.3	87.12	90.30	85.87	88.37
CRNA.4	84.03	86.87	82.66	85.40
CRNA.5	78.26	82.51	76.44	80.08
CRNA.6	73.62	79.25	71.37	75.87
CRNA.7	68.83	74.16	66.16	71.50
CRNA2 (15:00-06:00)	53.24	53.05	51.99	54.50
CRNA3 (09:00-17:00)	65.43	66.70	63.09	67.77
Ldr_crna	87.55	97.25	85.62	89.47
sac_anesmd	72.00	72.50	71.01	72.98
sac_CRNA	69.82	70.75	68.84	70.81

LEGEND

AnesMD1.............. Anesthesiologist Consultant

Anesthesiologist.... Anesthesiologist assigned to surgical patients

CRNA .... Certified Registered Nurse Anesthetist (CRNA) assigned to surgical patients

Ldr_crna CRNA ... Assigned to Labor and Delivery

sac_anesmd .... Anesthesiologist assigned to Surgical Admission Center

sac_CRNA .... CRNA Assigned to Surgical Admission Center

Table 3.

Descriptive Statistics for Three Assigned Anesthesiologist Consultants Model

Statistic (% Time Use)	Mean	Median	Low 90% CI	High 90% CI
AnesMD1	65.37	66.38	64.07	66.66
AnesMD2	49.33	49.63	47.64	51.02
AnesMD3	50.95	50.86	49.44	52.47
Anesthesiologist.1	82.23	85.74	80.52	83.94
Anesthesiologist.2	73.24	75.05	70.93	75.55
Anesthesiologist.3	64.17	68.67	61.07	67.28
Anesthesiologist.4	56.68	63.12	53.10	60.25
CRNA.1	91.08	93.75	90.11	92.06
CRNA.2	89.42	91.55	88.34	90.49
CRNA.3	86.05	89.71	84.72	87.37
CRNA.4	82.94	86.82	81.37	84.51
CRNA.5	79.90	84.10	78.16	81.63
CRNA.6	75.00	80.01	72.94	77.06
CRNA.7	69.34	74.14	66.90	71.77
CRNA2 (15:00-06:00)	53.23	53.59	52.05	54.42
CRNA3 (09:00-17:00)	64.87	66.80	62.47	67.27
Ldr_crna	87.45	95.21	85.67	89.23
sac_anesmd	70.02	70.72	69.07	70.96
sac_CRNA	67.90	69.04	66.90	68.90

LEGEND

AnesMD................ Anesthesiologist Consultant

Anesthesiologist.... Anesthesiologist assigned to surgical patients

CRNA .... Certified Registered Nurse Anesthetist (CRNA) assigned to surgical patients

Ldr_crna CRNA ... Assigned to Labor and Delivery

sac_anesmd .... Anesthesiologist assigned to Surgical Admission Center

sac_CRNA .... CRNA Assigned to Surgical Admission Center

Appendix C

ANOVA Table

Table 4.

ANOVA Results for Models 1-3

MDA Consultants (AnesMD)		Sum of Squares	df	Mean Square	F	P-value (sig)
	Between Groups	72704.34	2	36352.17	422.9097	1.5E-123
	Within Groups	64210.09	747	85.95728		
	Total	136914.4	749			
MDA Providers (Anesthesiologist)		**Sum of Squares**	**df**	**Mean Square**	**F**	**P-value (sig)**
	Between Groups	325.8973	2	162.9486	0.5656	0.5683
	Within Groups	215247.4	747	288.1491		
	Total	215573.3	749			
CRNAs		**Sum of Squares**	**df**	**Mean Square**	**F**	**P-value (sig)**
	Between Groups	43.77168	2	21.88584	0.2787	0.7569
	Within Groups	58669.33	747	78.53994		
	Total	58713.1	749			

Appendix D

Benchmarks

Table 5.

Benchmarks

	CRNA	MD
TDA	22	14
ASAM	23	13
MODEL	21	13

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